

Design Studies Towards a Reactor Neutrino Oscillation Experiment to Measure θ_{13}

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Recent experimental results indicate that neutrinos have a small but finite mass and change flavor. The phenomenon of neutrino mixing is characterized by the coupling between the neutrino flavor ($\nu_{e,\mu,\tau}$) and mass eigenstates ($\nu_{1,2,3}$) and the associated mixing angles. Previous neutrino oscillation experiments, including SNO and KamLAND, have determined two of the three mixing angles in the neutrino mixing matrix, U_{MNSP} .

During the past year an international working group [2] has studied the concept of a future reactor neutrino oscillation experiment to discover and measure the coupling of the electron neutrino flavor to the third mass eigenstate, U_{e3} . Recently proposed experiments plan to use the intense flux of $\bar{\nu}_e$ from nuclear power plants and measure the rate and energy spectrum of $\bar{\nu}_e$ interactions at different distances from the nuclear reactors. These experiments require the construction of underground detector halls and access tunnels for the placement of at least two medium-sized liquid scintillator detectors with a fiducial volume of about 25-50 t. Overburden in excess of several hundred meters water equivalent (mwe) is required to reduce cosmic-ray related backgrounds. Tunnels of up to 3 km in length or vertical shafts are to be built to access the underground detector halls. The relatively fast timescale and the modest project cost make the measurement of θ_{13} with reactor neutrinos particularly attractive.

The current best upper limit on U_{e3} comes from the CHOOZ reactor neutrino disappearance experiment [1]. In contrast to the surprisingly large mixing of the other neutrino states, the U_{e3} coupling was found to be small. Neutrino oscillation experiments play an important role in understanding the physics of massive neutrinos. The yet unknown mixing angle θ_{13} is one of the parameters of the Standard Model. A reactor experiment will allow a measurement of θ_{13} with no ambiguities due to matter effects and better precision than other proposed experiments. With a proposed sensitivity of $\sin^2 2\theta_{13} \leq 0.01$ a reactor experiment will provide important input to future oscillation studies at accelerators [3] and in combination with long-baseline accelerator experiments may give early indications of CP violation and the mass hierarchy.

Over the course of the past year the θ_{13} group at Berkeley has performed design and engineering studies for a future reactor neutrino experiment at two possible sites, the Diablo Canyon power plant in California and the Daya Bay reactors near Hong Kong, China. Both sites have a similar topography [4] with reactors located at coasts. The nearby coastal mountains provide up to 1200 mwe overburden. Negotiations with the reactor operators are underway to develop a proposal for the con-

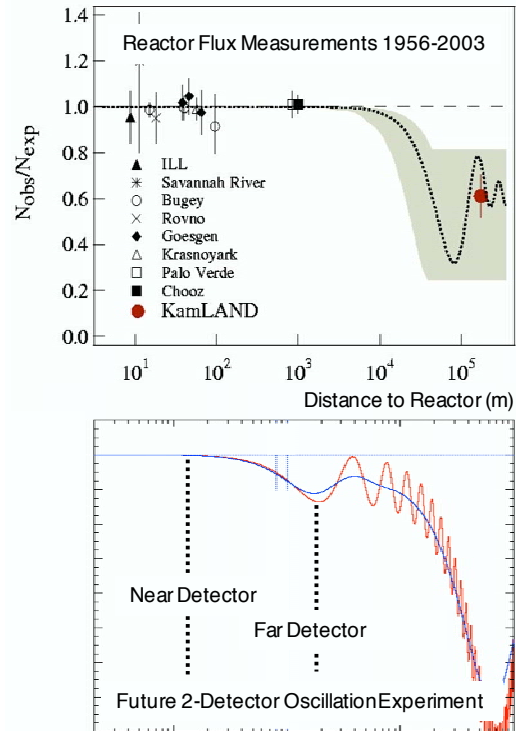


FIG. 1: Upper panel: Measurement of the absolute reactor $\bar{\nu}_e$ flux in past experiments at different distances from the source. Lower Panel: A 2-detector reactor neutrino experiment to determine the subdominant θ_{13} oscillation from a relative measurement of the $\bar{\nu}_e$ rate and energy spectrum at distances of 0.2-1.7 km from a nuclear reactor.

struction of next-generation neutrino oscillation experiment to measure θ_{13} with reactor $\bar{\nu}_e$'s. Berkeley Laboratory has formed a R&D partnership with the Institute of High Energy Physics in Beijing and other US institutions for design studies towards a future reactor neutrino experiment.

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 - [2] K. Anderson et al. (International θ_{13} Working Group), hep-ex/0402041, 2004.
 - [3] Report of the APS Reactor Working Group, <http://www.interactions.org/neutrinostudy/>
 - [4] <http://theta13.lbl.gov/>